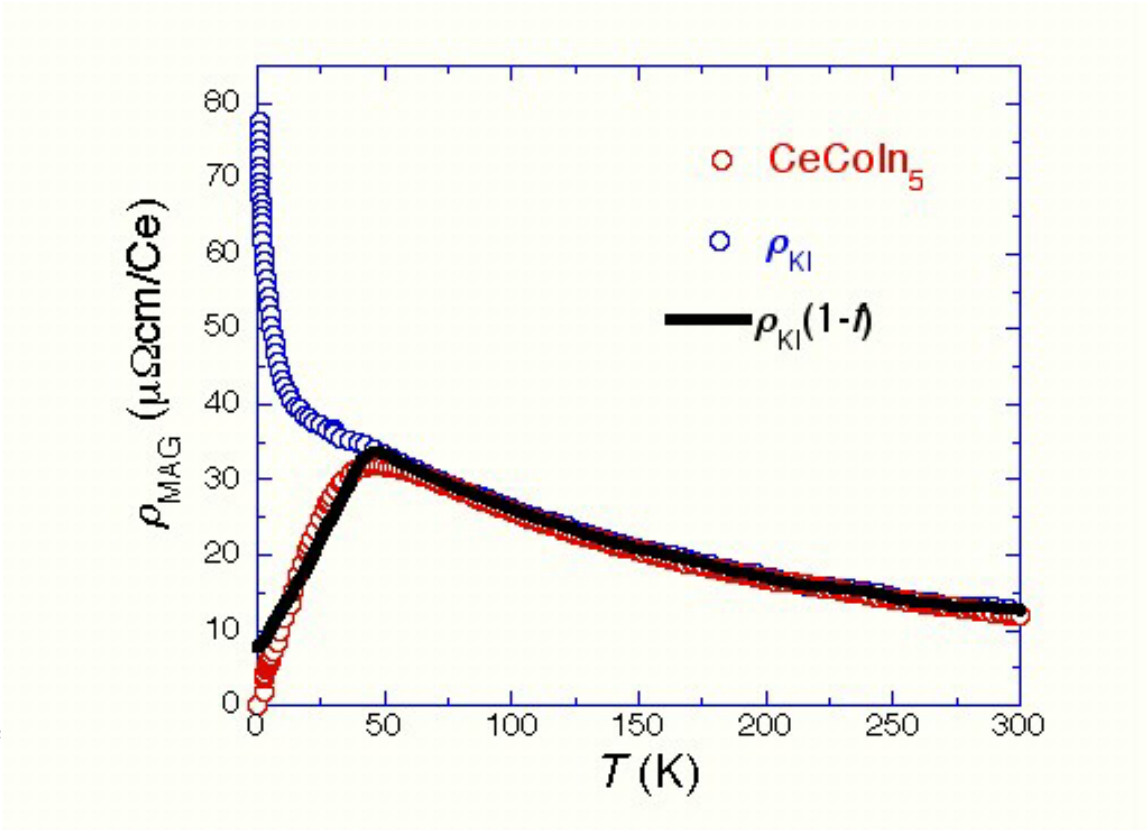
Cerium Ferromagnets at the Quantum Critical Point

Z. Fisk, Florida State University, DMR-0203214

Many exotic superconductors have been found to exist close to where a magnetic transition temperature approaches T = 0K. We have discovered that a good quantitative way to think about the low temperature properties of such materials is as a gas of magnetic centers interacting with conduction electrons which condenses into a correlated electron liquid as T → 0K. This condensation is incomplete, surprisingly, at the superconducting T_c for these exotic superconductors. The electrical resistivity of such materials is mainly due to magnetic scattering which our analysis finds simply measures the number of uncondensed magnetic centers present: the single ion resistance (blue) times the fraction present (the black curve being this product) gives the measured resistivity (red), the fraction being determined from the magnetic susceptibility and specific heat without reference to the resistivity.



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Broader Implications

The dense magnetic systems near the quantum critical point (ie $T_c \rightarrow$ 0K) that are the subject of our investigations have anomalous physical properties over a wide range in temperature and composition, and it is these unusual properties that could lead to technical electronic applications. The gas/liquid phenomenology provides a previously unavailable way to quantitatively distinguish and characterize materials within this important class of materials.

Education

This grant supports two graduate students, one graduating in 2003. A high school student has worked on this project in our laboratory, learning to grow crystals of intermetallics and make physical characterization measurements on the materials grown, including specific heat, magnetic susceptibility and electrical resistivity as well as x-ray powder diffraction patterns. Postdoctoral fellow Satoru Nakatsuji has been closely involved in this work, as have a wide variety of collaborators both at National Laboratories and universities.